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Crack Detection Of Beam Using Image Processing

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Abstract
The earliest sign of structure degrading is a crack in the surface of the concrete. This is important for maintenance because of the concrete and further exposure would seriously harm the environment. The preferred technique for crack determination is manual inspection. In the manual examination, the sketch of the crack is prepared manually, and the conditions of irregularities are noted. While manual inspection has traditionally been the preferred method, it relies heavily on the expertise of specialists and lacks quantitative analysis capabilities. So, Automatic image based crack determination is proposed as replacement. The Proposed system incorporates image processing and data acquisition methodologies for crack detection and assessment of surface degradation for crack detection and assessment of surface degradation. By comparing the proposed method with existing approaches, namely Talab's and Sattar Dorafshan Method, the accuracy and effectiveness of the proposed approach were evaluated. A dataset comprising 55 images of cracks from a 30-year-old building with a G+3 floor situated in a coastal area was utilized for validation. Images were captured using two different smartphone cameras with resolutions of 64MP and 20MP. The proposed algorithm, implemented in MATLAB R2023a. Results validate the efficiency of the proposed methodology is accurately detecting and assessing cracks, with an accuracy rate of 70% higher than that of the other two methods.
Keywords: *Area, Crack Detection, Degradation, Image processing, Surface degradation*

INTRODUCTION

The procedure of visual inspection and image processing is becoming more and more significant in civil and development engineering. Engineering constructions such as beams and concrete surfaces are frequently subjected to cyclic loading and fatigue stress, which causes cracks that typically start at the microscopic level above the surface of theconstruction. The structure's cracks result in material discontinuities and less local stiffness. Budiansky B. *et al.*, (1976). One of the earliest indicators and symptoms of deterioration is cracking in concrete surfaces. For the inspection, diagnosis, and renovation of concrete structures, crack detection is essential; however, conventional methods are unlikely to yield highly specific results because the image of the concrete flooring contains a variety of noise due to unique factors like concrete bless, stain, insufficient contrast, and shading. The typical method for inspecting cracks involves manually assessing the concrete's condition while simultaneously recording the details of the fractures in a separate format. The time-consuming information approaches, however, call for appreciation and involve complex computations. Conventional methods that don't take use of the fracture characteristics are unable to distinguish between crack and noise pictures, which prevents identification. For the inspection, diagnosis, and rehabilitation of concrete structures, crack detection is essential nevertheless, typical tactics should be aware that they do not always achieve very specific detection since the picture of the concrete does not constantly provide enough information. The inspection process typically necessitates access to the wall surface to facilitate thorough examination. Consequently, inspection techniques have seen increasing advancement over the past decade, enabling more efficient inspection procedures. When there is a leakage in a structure, it can potentially contribute to the formation or propagation of cracks. The cracks on the leakage surface occur due to moisture in the air that corrodes the reinforcement of the structure and after that the crack comes at surface level, it will affect the structure. In visual inspection, the result is created on person's skill. Cracks cause a measuring problem after a certain time period, so it is important to investigate the crack as soon as possible.
Hamish Dow et al. used Skeleton base noise removal algorithm. They used method which applies

an area threshold before reducing the pixel groups within the picture to a skeleton. Each skeleton is connected to its nearest before the remaining short skeletons within the picture are removed using a length threshold. Their proposed method is applied to make results of crack detection more reliable, supporting the ever-growing demand for automated inspections of constructions made of concrete Dow H. *et al.*, (2023).

Pham M. *et al.*, (2023) used automatic identification of ground crack propagation and measurement of their dimensions using a deep learning model and a method image processing. The deep learning models were trained and tested on an image data collection sourced from laboratory slope experiments and field crack images. Ground crack identified by the convolution neural network-based image segmentation models.

The external surface of the crack is analyzed for separation from the main profile, leveraging the features of a mixed over-complete dictionary comprising two types of atoms: one for crack representation and another for main profile representation. Shan B. *et al.*, (2015) utilized stereo vision cameras to capture the coordinates of crack edges. Image coordinates were obtained through the utilization of the Canny-Zernike algorithm. The crack width was evaluated using minimal crack edge detection techniques.

Yang Y.S. *et al.*, (2015).proposed a system to identify cracks automatically on the noisy concrete surface Images. The system includes two pre-processing steps and two detection steps.

Sinha S. *et al.*, (2006) investigated the cracks by using the two step approach. Their objective was to determine the crack surface. They have developed a statistical filter design for the crack detection. After filtering, the two-step approach at that the crack characteristics extraction was carried out at the preliminary stage of the pre-processing and then they have fused the images. The second step was to define the crack among the image segment by the procedure of cleaning and linking.

Talab's Method

The Talab's method is outlined in three main steps. Initially, the RGB image (I) is inverted to grayscale to simplify subsequent processing. Techniques for edge detection are then applied to extract prominent features indicative of cracks, followed by enhancement using the Sobel filter. In the next step, the edge-detected image is binarized using a suitable threshold (T) to distinguish between foreground (crack) and background pixels. In the third step, the Otsu method is employed for binarization, which automatically determines the optimal threshold value founded on the between-class variance of pixel intensities. This method maximizes the separation between foreground and background pixels, effectively enhancing crack detection accuracy. The Otsu method is applied by determining the threshold that minimizes the weighted sum of variances of two classes of pixels: foreground and background. By integrating these steps into the image processing pipeline, the proposed approach aims to enhance the accuracy and reliability of crack detection in optical fluorescent microscopy images Talab A. *et al.* (2016).

Sattar Dorafshan Method

The Sattar Dorafshan method for crack identification in images involves a sequence of actions, starting with reading the original RGB image directly from the camera. The image is then transformed to grayscale, and the surface is smoothed using a median filter. Sobel edge detectors are employed to enhance edges within the image, followed by the application of Otsu's thresholding method to generate a binary image. Connected object with an area less than 200 are identified and removed, and components with orientations of 0, 90, and -90 degrees are also removed. A morphological operation is applied. The modules of the original in the colour space of HSV are calculated, and pixels within the connected modules in the colour space of HSV are kept as candidate crack pixels. A new thresholding value is defined depend on the S values of the candidate crack pixels, and pixels are classified as either background (non-cracked) or cracked determined with the S values. The cracked pixels are detected, and the whole quantity of crack pixels is computed Sattar D.*et al.* (2016).

Proposed Method

This research is centred on image processing techniques to identify crack areas. The proposed system, as depicted in Fig. 1, comprises several steps: Acquisition, Enhancement, Analysis, Detection, Boundary Thickness, and Properties of Crack (Area).

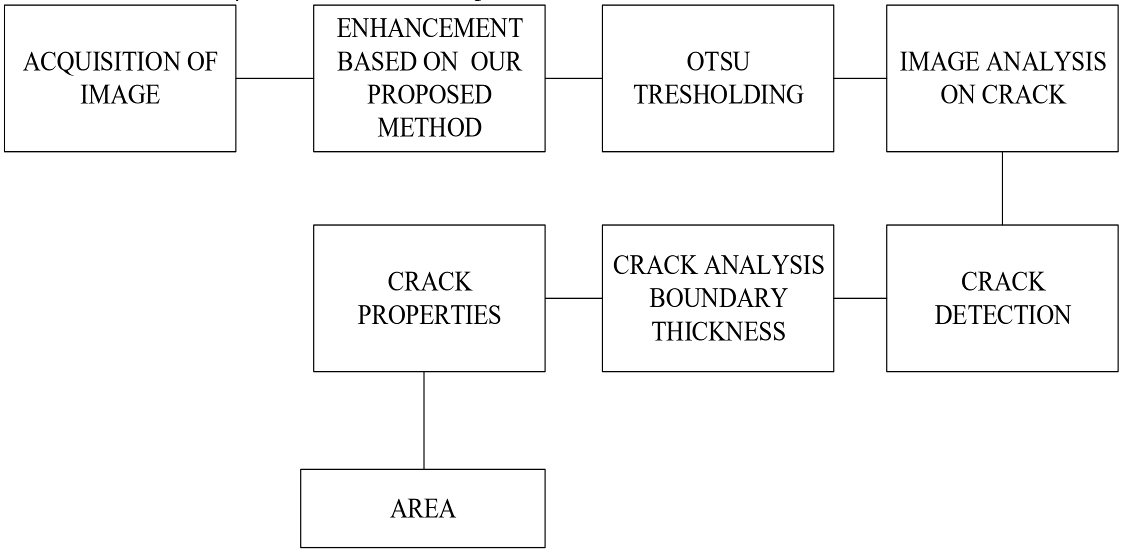

Fig .1 Flowchart of Proposed System

This study utilizes the images from Sattar Dorafshan's research to assess crack areas using a proposed methodology. This method's accuracy was evaluated by comparing it with those of Talab's and Safar Dorafshan Method. Then, 55 images of cracks were captured from a 30-year-old building of G+3 floor situated in a coastal area. These images were capture using two different smartphone cameras, one with a 64MP resolution and with a 20MP resolution. The RGB image with the extension "jpg" in any size used as the input for the suggested approach. The proposed algorithm was developed using the MATLAB R2023a programs.

The suggested approach operates in the spatial domain without the use of training or dye solutions, making it quick and effective. The essential concept behind this methodology was taken from Talab's method [Ahmed Mahgoub Ahmed Talab et al. (2016)]. The method of crack detection begins with taking a straight-out RGB image from the camera and moving on a grayscale image conversion. Easy image processing and analysis are made possible by this conversion. After obtaining the grayscale image, the surface is smoothed and noise is reduced by using a median filter. Sobel edge detectors are then used to sharpen the image's edges and highlight any crack Characteristics. The processed grayscale image is then transformed into a binary image utilizing Otsu's thresholding technique [Sattar Dorafshan, Marc Maguire, Xiaojun Qi (2016)]. Connected components having a region that is a smaller than 200 pixels is found and eliminated from the binary image. Additionally, connected components with orientations of 0, 90, and -90 degrees are identified and removed. A morphological process known as "majority" is used to improve the image. Next, objects with a total pixel count less than 50 are detected and removed. The original image's components are computed as we go into the Hue, Saturation, and Value colour space. Candidate crack pixels are defined as pixels located within the connected components in the Hue, Saturation, and Value colour space. Established on the candidate crack pixels' saturation (S) values, a new thresholding value is established. Next, the threshold value is compared through the S values of each candidate crack pixel. In the event that the S value of a potential crack pixel falls below the threshold, it is categorized as non-cracked background. The recognized cracks are finally represented visually by superimposing the fractured pixels on the novel image. To get binary a quantitative calculation of the extent or severity of the fracture, the whole quantity of crack pixels is also calculated.

The output of above process is displayed in Fig.3.

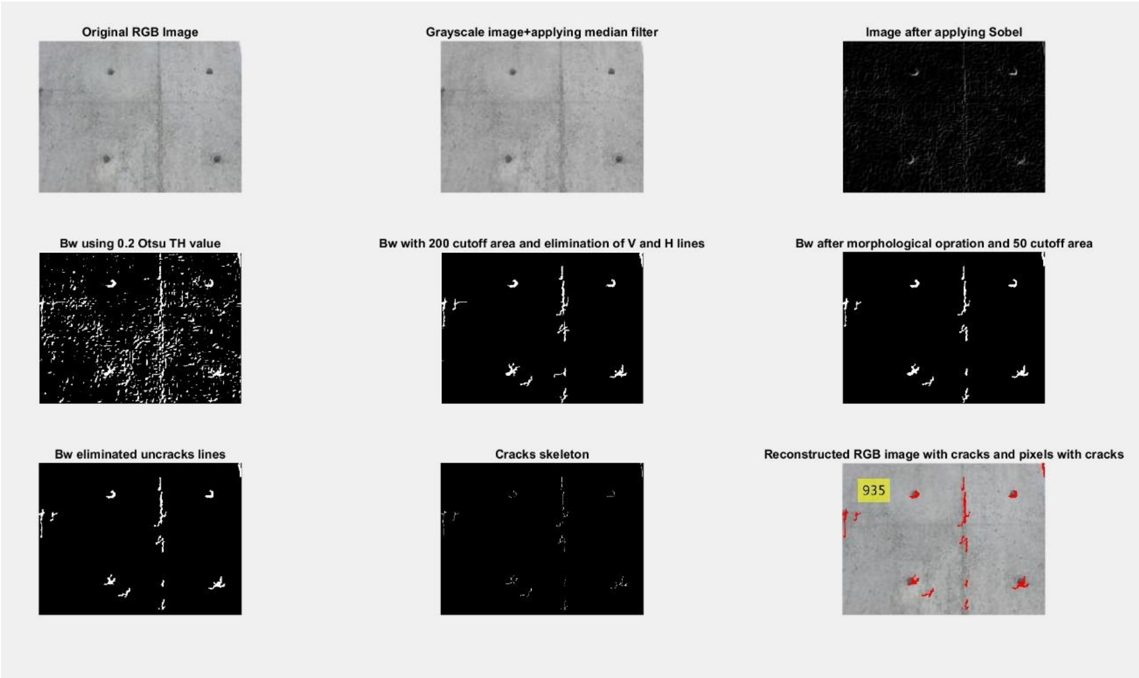

Fig.2 The reconstructed image with the proposed method

The comparison among three methods are shown in Fig.4.

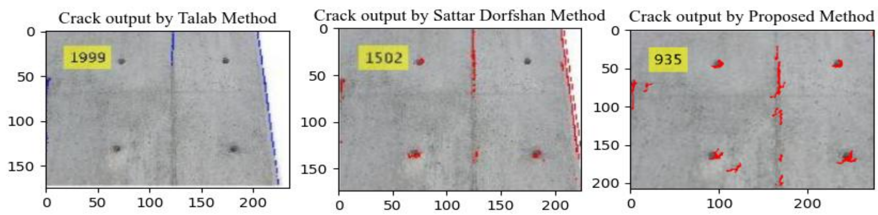

Fig. 3 Crack output comparison with Talab, Sattar method by proposed method

The proposed work for detection of crack utilizes image processing techniques and the Otsu method for binarization to enhance the correctness and reliability of crack detection in comparison to the methods proposed by Talab and Sattar Dorafshan.

RESULTS AND DISCUSSION

The crack outputs from the images captured from the 30-year-old structure, determined by the proposed method, are displayed in Fig. 4 and Fig. 5.

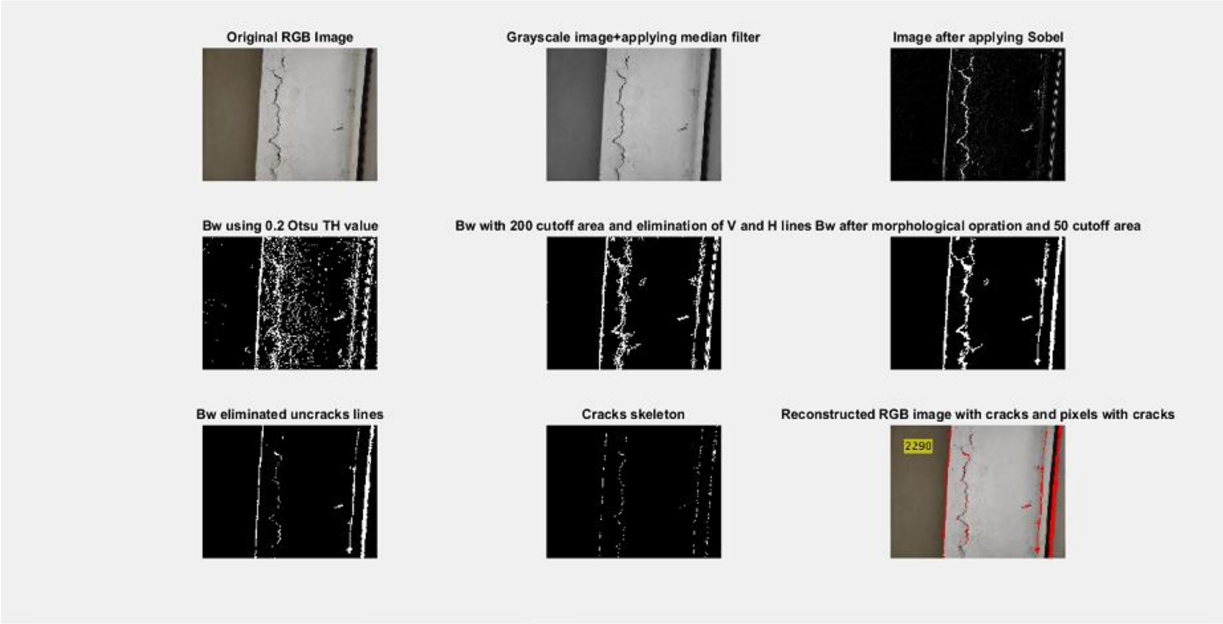

Fig.4 Result of Captured image of Beam 1

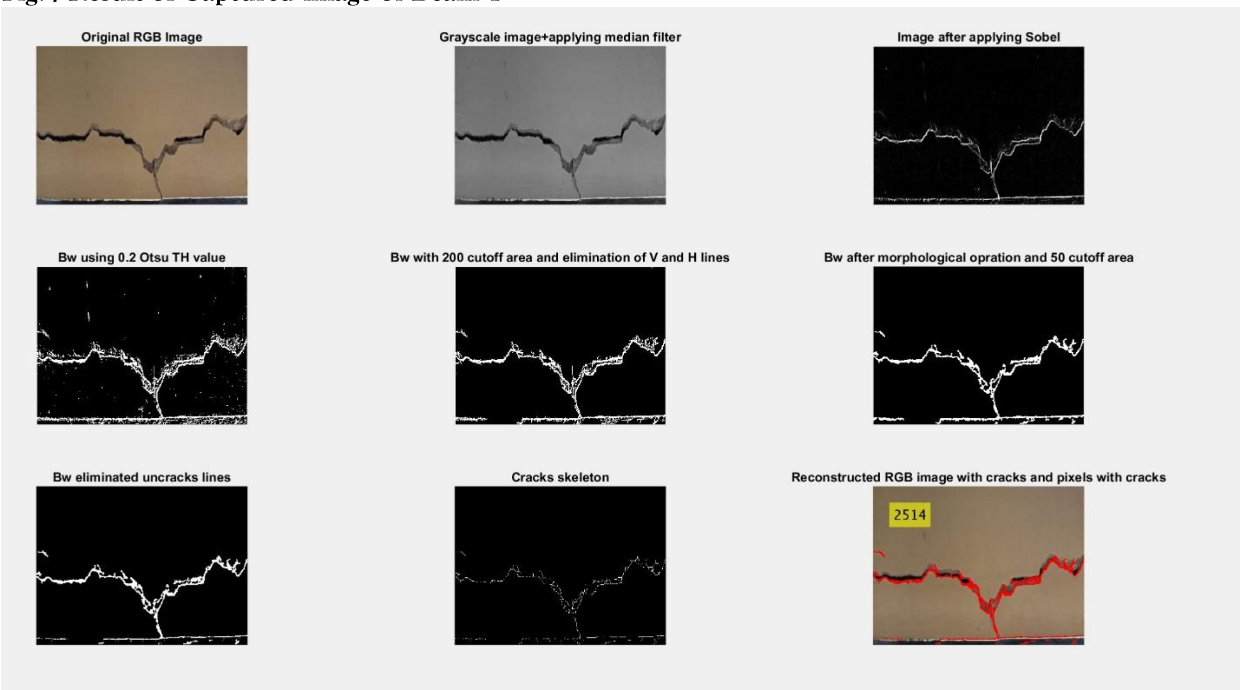

Fig.5 Result of Captured image of Beam 2

The crack results obtained from images captured at the 30-year-old Structure situated near the coastal area are shown in Table 1.

Table 1 Identified Crack of Beam

Sr No.	Component of Image	Mega pixels	Area (mm^2)
1.	Beam 1	64MP	2290
2.	Beam 2	20MP	1874
3.	Beam 3	20MP	770

The table offers crucial details regarding each identified crack occurs on the beam, including their sizes in square millimeters and the image resolutions used to capture them. The area of a crack is the total surface crack's area as measured from the image. It gives an indication of the extent of damage caused by the crack. Larger values in this column suggest that the crack covers a region of the beam's surface, indicating potentially more significant structural damage. If the crack area is more, it generally indicates a larger and potentially more significant crack on the beam. Larger crack areas can have several implication.

A larger crack area may indicate a more severe level of structural damage, and the beams load carrying capacity may be compromised. As the crack area increase the structural stability of the beam compromised.

CONCLUSION

The proposed crack detection approach in this study has an accuracy rate of 70%, which is more than the accuracy rates of the Talab and Sattar Dorafshan methods. This was discovered after comparing the proposed method with the former two methods. Challenges addresses such as algorithm implementation, lighting conditions, thin cracks, location variance, and data availability to enhance the accuracy of crack detection systems.

In the beams mentioned, the cracks have areas ranging from 770 to 2290 mm^2, using corresponding image resolutions of 20MP and 64MP. This suggests that the higher resolution images may provide added detailed information about the cracks, potentially aiding in their detection and measurement. However, the existence of shadowed regions or other interfering factors of the image can also impact the accuracy of crack detection and measurement. If a camera of low resolution is used, there will be an increase in errors with a rise in the distance away from the surface, especially for smaller cracks. Further improvement is required to increase an efficiency of the image.

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Data availability : Dataset were used for validation from previous papers and for Analysis dataset of 56 Images are generated from 30 years old building which is located in Maharashtra.

Abbreviations

T- Threshold
V- Value
H-Hue
S- Saturation

Declaration

Conflict of Interest The author Declare that they have no conflict of interest.

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